MeadWestvaco

TECHNOLOGIES, COSTS, AND PERFORMANCE OF WASTEWATER BOD AND TSS IMPROVEMENT OPTIONS FOR THE MEADWESTVACO RUMFORD MILL

August 13, 2003

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EXECUTIVE SUMMARY

LD1137, "An Act Regarding Riverine Impoundments," provides the Department of Environmental Protection (DEP) with the authority to adopt a compliance depth for dissolved oxygen in stratified riverine impoundments, including Gulf Island Pond. The Department must evaluate and consider physical, chemical, biological, and economic factors prior to establishing a compliance depth. The Department has chosen to establish a stakeholder group to participate in this process. This report provides information regarding the capacity and costs of technologies to reduce effluent BOD and TSS at the Rumford mill without an evaluation of whether the implementation of these technologies is recommended. There are four general questions that are addressed and answered in this report:

1. *Why are DEP's proposed "actual" BOD and TSS discharges more stringent than the Rumford Mill's current performance?* The DEP's proposed BOD and TSS discharges that are characterized as "actual" discharges in the Androscoggin River Modeling Report are unrealistic for the mill's current performance. A large number of violations would occur each year, unless substantial capital improvements were made to reduce effluent BOD and TSS discharges to meet DEP's modeled limits. In fact, adoption of the DEP's proposed "actual" discharge limits would position the mill to have more violations than any integrated pulp and paper mill in the nation because these limits do not accurately license the mill's current performance.

2. *What technologies and associated costs would be required to achieve compliance with DEP's modeled BOD and TSS limits?* The DEP's modeled BOD and TSS limits would not be attainable by MeadWestvaco without appreciable capital investments. Of the many technologies reviewed, the most viable option to achieve compliance with the DEP's modeled limits would be to increase the aeration basin size by a factor of approximately two. The initial cost estimate for capital expenditure is approximately $12.6 million.

3. *What other technologies, including mill process changes, were considered to meet the DEP's modeled BOD and TSS limits?* A total of 20 technologies/options were evaluated with regard to achieving compliance with the DEP's modeled BOD and TSS limits. This technology review demonstrates that increasing the wastewater treatment plant size provides a more economical and more proven effluent reduction option than mill process modifications.

4. *What BOD and TSS limits could the Rumford Mill achieve with limited economic impact?* Although the Rumford Mill's current summer BOD and TSS license limits are already below EPA Best Conventional Pollutant Control Technology limitations, the Rumford Mill has proposed lower license limits. MeadWestvaco is prepared to work towards sustainable compliance with these alternate license limits through investments in improved Best Management Practices and other process improvements.

MeadWestvaco is a responsible steward of dissolved oxygen in Gulf Island Pond. The mill's contribution to oxygen addition with the existing diffuser more than compensates for the oxygen demand that the mill's treated effluent creates. Additional expenses for oxygen injection or modifications for discharge reductions compensate for poor pond mixing and are not warranted based on the mill's dissolved oxygen impacts.

INTRODUCTION

LD1137, "An Act Regarding Riverine Impoundments," provides the Department of Environmental Protection (DEP) with the authority to adopt a compliance depth for dissolved oxygen in stratified riverine impoundments, including Gulf Island Pond. The Department must evaluate and consider physical, chemical, biological, and economic factors prior to establishing a compliance depth. The Department has chosen to establish a stakeholder group to participate in this process.

The purpose of this report is to provide information regarding the range of possible wastewater improvement options capable of reducing effluent BOD and TSS loadings from the MeadWestvaco Rumford Mill to the Androscoggin River. There are four general questions that are addressed and answered in this report, as listed below.

1. Why are DEP's proposed "actual" BOD and TSS discharges more stringent than the Rumford Mill's current performance?

2. What technologies and associated costs would be required to achieve compliance with DEP's modeled BOD and TSS limits?

3. What other technologies, including mill process changes, were considered to meet the DEP's modeled BOD and TSS limits?

4. What BOD and TSS limits could the Rumford Mill achieve with limited economic impact?

The report is divided into four sections: an Executive Summary, an Introduction, a Question and Answer section, Conclusions and Recommendations section, and associated Appendices. The report may be amended and reissued after receiving questions and comments from the Department and stakeholders.

QUESTIONS AND ANSWERS

Question 1: Why are DEP's proposed "actual" BOD and TSS discharges more stringent than the Rumford Mill's current performance?

Answer

The DEP's modeled "actual" BOD and TSS discharges (referred to herein as DEP's modeled limits) contained in the Androscoggin River Modeling Report are not equivalent to the mill's current performance. A large number of violations would occur each year, unless substantial capital improvements were made to reduce effluent BOD and TSS loadings to meet DEP's modeled limits.

The first step in understanding this issue is to review the mill's wastewater treatment plant performance. The mill has been operating well within license limits over the past five years, and has expended significant resources to continually improve performance. As a result of these efforts, the mill has experienced only one BOD and zero TSS discharge exceedances during the last five years.

The Rumford Mill has chosen to operate the mill process and mill's treatment plant process in a manner that maintains the highest treatment efficiencies and the lowest discharges to the Androscoggin River. The mill routinely operates at 10 to 25% of its licensed limits. This conscious decision to operate in this manner comes at considerable expense. The Rumford Mill could have easily decreased treatment plant performance as well as other aspects of mill operation to reduce cost. A conservative estimate is that the Rumford Mill incurs additional operating cost of approximately $700,000 per year to operate at current levels versus operating near its licensed limits. Direct costs are incurred for operating at higher efficiencies in the wastewater treatment plant and utilization of chemical addition to minimize losses. Other direct costs are incurred from environmental procedures impacting the productivity of the mill operation. Many additional indirect costs cannot be quantified, such as mill capital and strategic facility planning has been based on maintaining this level of performance. Alternate engineering options may have been viable in lieu of the $8 million brownstock washer upgrade, $6 million steam stripper, as well as multiple heat and flow reduction projects, and effluent treatment plant aeration upgrades.

The mill has voluntarily reduced its discharge of BOD and TSS to the Androscoggin River by 67% and 70%, respectively since 1987. This achievement was recognized with a Governor's Award for Environmental Excellence in Pollution Prevention in 2001. The mill BOD, TSS, flow, and phosphorus discharges are consistently better than median industry discharges tracked by the National Council for Air and Stream Improvement (NCASI).

The Rumford Mill has consistently incorporated strategic environmental planning into the mill's long term facility planning. As an example, in 2001, rather than retrofitting existing antiquated equipment, the Rumford Mill completed the installation of a state of the art, brownstock washing system. The new washing system reduced fresh water usage, reduced wastewater pollutants from pulping and bleaching, and reduced air emissions. In just the last 5 years, the Rumford Mill has spent $18 million on environmental improvements.

These process improvements and wastewater reductions, coupled with the mill's contribution to oxygen addition in Gulf Island Pond, means that the mill makes a net improvement to the dissolved oxygen in Gulf Island Pond.

Table 1 details the number of license exceedances (nearly zero) that have occurred during the last five years. MeadWestvaco has an environmental compliance policy of "no violations." This policy translates into accountability at every level of the organization, and is consistent with the mill's approach to maximizing the effectiveness of their treatment operations.

Table 1 - Summary of Actual License Exceedances Over Last Five Years

	Daily BOD	Daily TSS	Monthly BOD	Monthly TSS	Total Violations
1998	0	0	0	0	0
1999	0	0	0	0	0
2000	0	0	0	0	0
2001	1	0	0	0	1
2002	0	0	0	0	0
Total	1	0	0	0	**1**
Average	0.2	0.0	0.0	0.0	**0.2**

Table 2 lists the number of license exceedances that would have occurred over the last five years if the DEP's modeled limits had been in place. The modeling report limits applied to present performance would translate into 50 violations over the last five years, with a peak of 16 violations in one year.

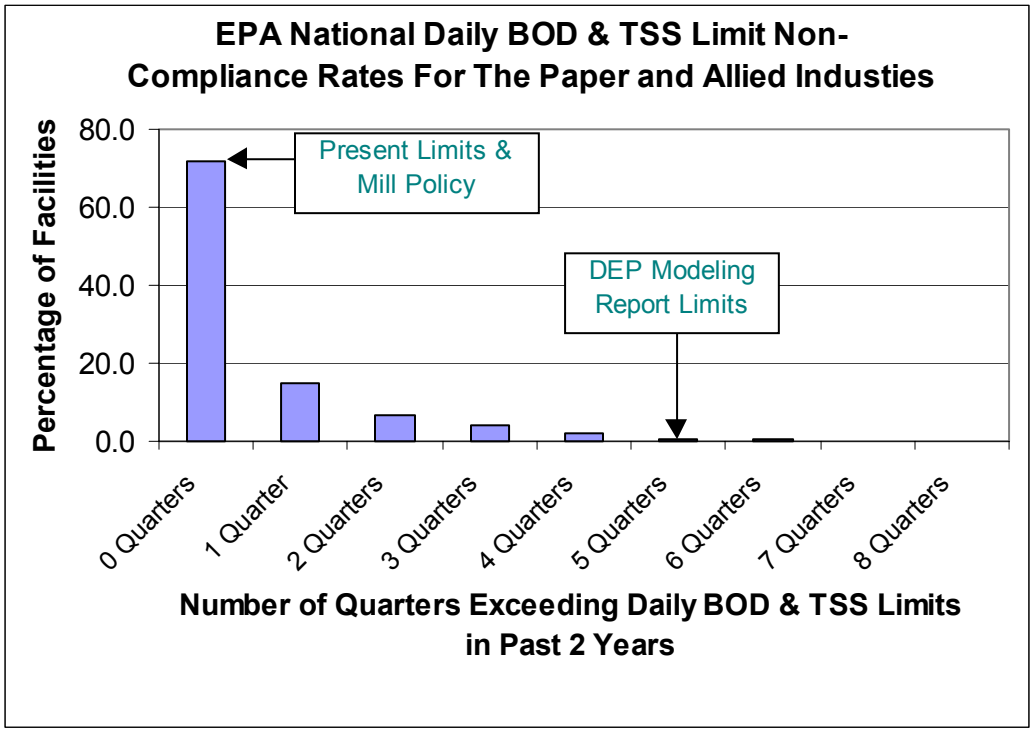
Table 2 - Summary of License Violations if DEP's Modeled Limits Had Been in Place

	Daily BOD	Daily TSS	Monthly BOD	Monthly TSS	Total Violations
1998	4	7	2	3	16
1999	2	5	1	0	8
2000	0	0	0	0	0
2001	4	7	0	0	11
2002	2	12	0	1	15
Total	12	31	3	4	**50**
Average	2.4	6.2	0.6	0.8	**10**

Nationwide compliance data for BOD and TSS was obtained from the EPA Enforcement and Compliance Online (ECHO) database available on the EPA web site. Non-compliance data for all Paper and Allied Products sector facilities considered to be major sources was reviewed for BOD and TSS. The ECHO system provides the number of quarters out of the most recent 8 quarters with one or more violations of the daily BOD or TSS license limits. This number was tabulated for every discharger considered by ECHO to be a major facility in the Paper and Allied Products sector.

Figure 1 shows that the mill presently resides in the "zero violation" category, along with the majority of other mills. Implementation of the DEP's modeled limits would result in a projected average of five violations out of every eight quarters, placing the mill in a category that exceeds nearly every facility identified in the Paper and Allied Products sector.

Figure 1 - EPA National Daily BOD & TSS Limit Non-Compliance Rates for the Paper and Allied Industries



Again, this emphasizes the fact that the DEP's modeled limits do not accurately characterize the Rumford mill's present discharge performance, and adoption of these standards would result in a compliance record in the bottom 1% of the paper and allied products sector. In fact, adoption of the DEP's proposed "actual" discharge limits would position the mill to have more violations than any integrated kraft pulp and paper mill in the nation because these limits do not accurately license the mill's current performance.

Question 2: What technologies and associated costs would be required to achieve compliance with DEP's modeled BOD and TSS limits?

Answer

The DEP's modeled BOD and TSS limits would not be attainable by MeadWestvaco without appreciable capital upgrades. A large step change reduction in BOD and TSS discharge, rather than small incremental improvements, would be required to achieve and sustain compliance with the DEP's modeled limits. Of the many technologies reviewed, the most viable option to achieve compliance with the DEP's modeled limits would be to increase the aeration basin size by a factor of approximately two. The initial cost estimate for capital expenditure is approximately $12.6 million.

The mill's secondary clarifiers handle a relatively large quantity of activated sludge solids, and are operating near the upper limit of their practical solids loading rate range. This is driven by two factors: (1) the size of the clarifiers; and (2) the relatively high Mixed Liquor Suspended Solids (MLSS) concentrations required to maintain a healthy Food-to-Microorganism ratio in the aeration basins.

An option to reduce the mill's effluent BOD and TSS loadings involves roughly doubling the volume of the aeration basins. This would allow the plant to operate at half its present MLSS concentration, thereby appreciably reducing the solids loading rate on the secondary clarifiers. The result would be tighter control of sludge blanket levels and fewer upset conditions in the secondary clarifiers. Detailed review of historic operating data demonstrates that the majority of days with elevated BOD or TSS discharges are related to: 1) uncontrollable secondary sludge blanket levels due to increased TSS losses 2) increased particulate BOD, or 3) filament destruction methods to proactively control blanket settleability. Doubling the aeration basin size would serve to address these conditions and; therefore, greatly reduce the potential for violating the DEP's modeled license limits.

There is some level of risk involved in this option due to the limited space available at the mill site. Should unforeseen conditions be encountered at the proposed location, installation costs could dramatically increase or other more expensive site locations may be required.

The DEP's modeled limits may be attained by increasing the aeration basin capacity for a cost of $12.6 million. There will be increases in cost to operate and maintain the new 30 foot deep basin and associated equipment. An unknown amount of this cost will be offset with improvements in treatment efficiencies. An approximate operating cost increase is $200,000 per year. Investments in tighter process control via enhanced on-line monitoring and other continuous improvement measures is likely in conjunction with these major capital upgrades as described in Question 4.

<u>Question 3</u>: What other technologies, including mill process changes, were considered to meet the DEP's modeled limits?

<u>Answer</u>
A number of additional technologies/options were evaluated with regard to achieving compliance with the DEP's modeled BOD and TSS limits. A total of 20 different technologies/options were reviewed. The most viable option was previously presented and discussed under Question 2. Brief conceptual reviews and cost estimates of the design approaches not selected are provided in Appendix A.

As part of this evaluation, it is important to recognize the significant environmental technologies already installed by the Rumford Mill. These projects have already resulted in improved wastewater loading from the mill and have reduced BOD loading to the treatment plant to within optimal ranges for maintaining high BOD removal efficiencies. In just the last 5 years, the installation of a $6 million steam stripper for condensate treatment and an $8 million brownstock washer have each contributed significantly to optimizing BOD loading to the wastewater treatment plant. These projects are part of the extensive list of improvements that have helped the mill achieve a 67% and 70% reduction in discharges of BOD and TSS, respectively. Additional reductions in BOD loading from the mill produce only marginal gains in effluent discharge as shown in Option 4 of Appendix A. This review demonstrates that increasing the wastewater treatment plant size provides a more economical and more proven effluent reduction option than mill process modifications could provide.

Question 4: What BOD and TSS limits could the Rumford Mill achieve with limited economic impact?

Answer

The mill has committed significant resources to achieving sustainable environmental compliance and continuous improvement. For this reason MeadWestvaco has approached this process with a willingness to accept more stringent license limits than its current limits. The Environmental Protection Agency has established nationwide effluent limitations based on Best Conventional Pollutant Control Technology (BCT) and Best Practicable Control Technology (BPT). These technological performance standards were most recently evaluated by EPA during the Effluent Guidelines rulemaking (Cluster Rules). As stated in the preamble to the final rule, EPA chose not to further reduce these performance standards since "the total cost of applying the proposed BPT model technology is disproportionate in this instance to the effluent reduction benefits achieved." Similarly, EPA reviewed BCT options and concluded that "none of the candidate options passed the BCT cost test."

Interestingly, the Rumford Mill's current license limits are already well below EPA BPT/BCT limitations. MeadWestvaco has proposed attainable wastewater limits in Table 3 below. These proposed limits were modeled by the Department in April 2003 (referred to herein as April 2003 Modeling Run limits). Table 3 lists the Rumford Mill's current license limits, BPT/BCT limitations, along with the reductions attainable by MeadWestvaco.

Table 3 - BOD & TSS Limits

Limit	Federal BCT/BPT Limitations (lb/day)	Current License Summer (lb/day)	MeadWestvaco Attainable Limits – April 2003 (lb/day)	Reduction from Current Summer License Limits
Daily BOD	42,400	20,000	18,000	10%
Monthly BOD	22,000	12,000	9,000	25%
Daily TSS	88,600	61,400	40,000	33%
Monthly TSS	47,600	32,900	15,500	51%

Table 4 summarizes the results of an analysis to evaluate the BOD and TSS violation rate that would have occurred over the last five years had these April 2003 Modeling Run limits been in place. The average of two violations per year would be the worst in the Corporation and the worst of any Maine mill. These limits would result in an average of two out of every eight quarters with a daily BOD and TSS violation. These limits are stringent and would promote improvement efforts, since these limits would place the mill near the bottom of the EPA nationwide compliance database – 10^{th} percentile.

Table 4 - Violation Rate Analysis for April 2003 Modeling Run Limits

	Daily BOD	Daily TSS	Monthly BOD	Monthly TSS	Total Violations
1998	2	1	0	0	3
1999	2	2	0	0	4
2000	0	0	0	0	0
2001	1	0	0	0	1
2002	1	1	0	0	2
Total	6	4	0	0	**10**
Average	**1.2**	**0.8**	**0.0**	**0.0**	**2**

MeadWestvaco considers this performance unacceptable, and will require additional resources to be applied to satisfy corporate policy and achieve sustainable compliance. In spite of this compliance risk, MeadWestvaco believes that these limits can be achieved and the company is willing to accept the April 2003 modeling run limits. Significant resources will be required to work towards sustainable compliance with these limits through pollution prevention, best management practices for process losses, and enhancement of wastewater treatment controls.

The Rumford mill has a history of successfully implementing pollution prevention projects, improving performance by adopting best management practices, and integrating environmental objectives with the mill's long term facility planning process. Examples of this success with wastewater include a 67% reduction in effluent color, as well as the 67% and 70% reductions in effluent BOD and TSS. Overall, the mill has reduced its releases of toxic substances to the environment by 84% since 1990.

The Rumford treatment plant is a high-rate activated sludge system with approximately 6 1/2 hours of retention time in the aeration basin and 4 1/2 hours of retention time in the secondary clarifiers. High rate plants are less forgiving, and require more sophisticated, reliable process control monitoring than lower rate facilities. Effective measurement and control of process losses and wastewater treatment activities must be faster than the typical treatment plant in the industry, since the plant variables are more dynamic.

Many key operating parameters are currently monitored periodically in the field or in the lab. Measurement and control strategies could be improved through the use of real-time monitoring of these parameters. The mill would need to evaluate which real-time monitors would provide the greatest benefit, possibilities include: secondary clarifier blanket levels, phosphorus residual levels, dissolved oxygen concentrations, effluent TSS and/or turbidity concentrations, and influent color, turbidity, and/or conductivity. Improved chemical addition systems could also be employed, including a coagulant/polymer addition system at the primary, as well as coagulant, polymer and bentonite systems at the secondary clarifiers. A projected total equipment cost to implement these types of improvements would be approximately $600,000 with an operating cost increase of $150,000 per year.

Despite the fact that the limits are well below Federal BPT/BCT limitations, MeadWestvaco is willing to accept the license limits presented April 2003 Modeling Run. MeadWestvaco will be accepting risk and will need to commit significant resources to achieving sustainable compliance with these proposed limits.

CONCLUSIONS AND RECOMMENDATIONS

The Rumford Mill has chosen to operate the mill process and mill's treatment plant process in a manner that maintains the highest treatment efficiencies and the lowest discharges to the Androscoggin River. This conscious decision to operate in this manner comes at considerable expense. The Rumford Mill could have easily assumed a high risk position and decreased treatment plant performance and certain aspects of mill performance to reduce cost. In addition to the chemical, electrical, mechanical, and employee costs of operating in this manner, the mill has also invested $18 million in the last five years on environmental projects. Overall, the mill has reduced its discharges of BOD and TSS by 67% and 70%. The Rumford Mill has incurred only one BOD and zero TSS violations in the last 5 years.

The BOD and TSS limits modeled by DEP are more stringent than the Rumford Mill's current discharge levels. If MeadWestvaco were required to adopt these proposed limits, the mill would incur significant violations. This would require significant investments in the mill's waste treatment plant to reduce BOD and TSS to a level where sustainable compliance could be achieved. A cost of $12.6 million would be required to increase the size of the wastewater treatment plant. BOD and TSS reductions at the Rumford mill are not cost effective means of increasing the depth of oxygenated water in Gulf Island Pond.

Even though the current summer BOD and TSS limits are already more stringent than Federal BCT limitations, the mill has proposed to accept even lower BOD and TSS license limits. Compliance with these lower limits could be achieved with investments in additional best management activities and process improvement investments beyond the $700,000 cost per year already voluntarily incurred to outperform the present license limits. Examples could include the installation of various additional on-line monitoring systems and permanent chemical addition systems for an estimated capital investment of $600,000.

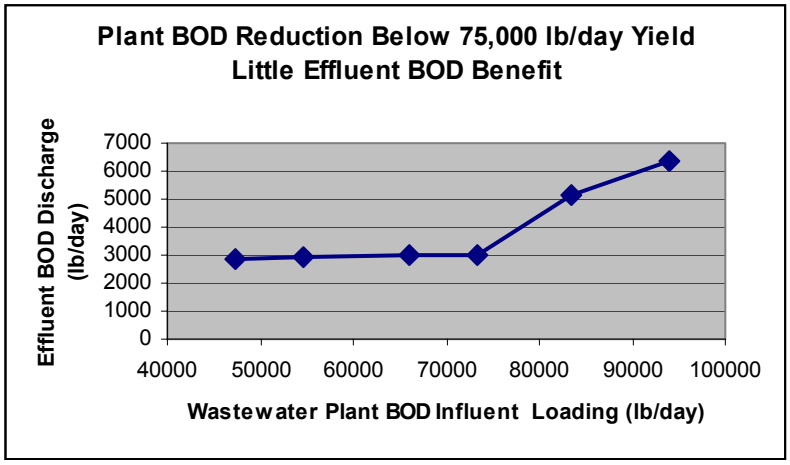
The mill is a responsible steward of dissolved oxygen in Gulf Island Pond. The mill's contribution to oxygen addition in the existing diffuser more than compensates for the oxygen demand that the mill's treated effluent creates. Additional expenses for oxygen injection or modifications for discharge reductions are to correct for poor pond mixing and are not warranted based on the mill's dissolved oxygen impacts.

APPENDIX A – TECHNOLOGY REVIEW

1. *Continuous Improvement/Best Management Practices (BMP)/Pollution Prevention* – The mill has made significant gains with continuous improvement, pollution prevention activities, and development and implementation of BMPs. This report specifically identifies opportunities for additional progress; however, these continuous improvement efforts are not judged as sufficient to reduce from a peak of 16 violations per year of the Modeling Report limits to zero.
2. *Added Secondary Clarifier Capacity* – Reducing the solids loading rate of the secondary clarifiers is key to reducing the frequency of operating days above the targeted discharge rate in the Modeling Report. Doubling the secondary clarifier capacity would directly improve this solids loading; however, space is unavailable adjacent to the existing secondary clarifiers so this option was eliminated.
3. *General In-Mill Flow Reduction* – The significant majority of days of elevated BOD or TSS days relate to the performance of the secondary clarifier either due to increased TSS (high sludge blanket levels), increased insoluble BOD, or filament destruction methods required to control sludge blanket levels. Therefore, the secondary clarifier's solids specific loading rate (lb solid/day/sq.ft.) is a key metric for judging process changes. Reducing the frequency of discharges above the Modeling Report values from 16 per year to zero requires a substantial change of this specific loading rate. Doubling the aeration basin volume drops this loading rate in half by reducing the required MLSS concentration by a factor of two.

   The European Union's Integrated Pollution Prevention Control (IPPC) report on the best achievable techniques in the pulp and paper industry list multiple mills for comparison. As expected, all the linerboard and market pulp mills have low process water usage (<50 cubic meters/metric ton of finished product) while the two integrated pulp and paper mills listed operated at 61 and 77 cubic meters per metric ton of finished product on an annual basis. Based upon the 2002 Rumford mill annual average finished product daily production, the annual average flow for a 61 cubic meter/metric ton to match these highlighted integrated bleach kraft pulp and paper mills would require a 10% reduction in flow. Since cooling towers, pipes, pumps, controls, etc would be needed to attain this flow reduction to maintain mill water and wastewater plant temperatures within acceptable operating ranges, a rough cost is a couple million dollars. Reducing flow to levels competitive with the best North American and highlighted European integrated pulp and paper mills only reduced the secondary clarifier solids loading 10% while doubling the aeration basin cuts this loading in half. Flow reduction is insufficient to attain the Modeling Report limits.
4. *Generalized In- Mill BOD Reductions* – The Rumford mill has reduced the mill's wastewater treatment plant BOD loading appreciably using Best Management Practices, the $6 million installation of the condensate steam stripper, and the recent $8 million installation of a DD washer for improved brownstock washing and screen room closure. These changes have reduced the BOD loading to the treatment plant considerably. The following graph has been filtered or "smoothed" by averaging 5 years of monthly BOD loadgs entering the treatment plant and relating it to the corresponding average effluent BOD discharges. A wide range of BOD loadings were observed, including data prior to mill improvements, as well as BOD loadings occurring during paper machine market downtime and associated reduced pulp/bleach production rates. The conclusion is that little benefit is realized by further reducing BOD loading below what has already been achieved. The mill is currently operating with an average BOD loading below 70,000 lb/day.

Additionally, large investments (>$50 million) would be required to reduce the mill loading by 30% via bleaching sequence changes and other process changes; yet, the solids loading to the secondary clarifier would be reduced by only about 25% (<30% since some loading is due to mill losses). While a 25% specific loading reduction may not provide the needed clarifier offloading, doubling the aeration basin volume cuts the loading rate in half with a lower cost.



5. *Combined In-Mill Reduced BOD and Flow* – Since flow reduced the clarifier specific loading 10% and major BOD reductions would reduce the loading 25%, the combination would reduce the loading by approximately 35%. This approach may or may not be sufficient to meet the Modeling Report limits; however, this approach (>$55 million for bleaching changes and flow reduction) is substantially more costly than increasing the aeration volume which cuts the loading by half.
6. *Trickling Filter Pretreatment* – Achieving equivalent clarifier loading reductions with a trickling filter prior to the secondary treatment system is technically achievable and probably costs less than increasing the aeration basin volume. However, the technology is known to produce odors so was eliminated as a choice since this in contrary to the mill's continuing progress and capital expenditures to reduce overall odor.
7. *MBBR Pretreatment* – A Moving Bed Biofilm Reactor (MBBR) would reduce the mill BOD loading. However, the costs are similar to the aeration basin expansion since the savings of a smaller volume are offset by the costs of purchasing the media. Since this provided no savings, the conventional aeration technology was preferred.
8. *MBBR Bleach Plant Pretreatment* – Thermophilic MBBR technology would cost approximately $8 million to provide a pretreatment reduction of BOD of 50% from the bleach plant wastewater stream. The BOD removed by MBBR is likely the type of BOD that is more readily biodegradable and is already removed efficiently by the treatment plant. The technology to achieve this 50% reduction in the bleach plant wastewater BOD is less expensive than the bleaching sequence modifications that were reviewed; however, it provides only a 20% reduction in overall mill influent BOD which is insufficient to substantially offload the secondary clarifiers.
9. *Polymer/Coagulant to Primary Clarifier & Inorganic Loss Reductions* - A fraction of inorganic losses such as those from paper coatings may pass through the primary clarifier and add to the biologically inactive solids load to the secondary clarifier. Reductions in mill losses through ongoing pollution abatement efforts are recommended. A polymer/coagulant combination in the primary

clarifier during high losses may assist the plant; however, this combination has a high operating cost and will not sufficiently offload the secondary clarifiers.

10. *Polymer/Coagulant to Secondary Clarifier* – Installing a permanent, readily available, reliable polymer/coagulant system will improve existing systems for managing high losses. Presently polymer is metered in when sludge blankets are high. During times when polymer alone is insufficient, bentonite is added as a coagulant to assist in reducing clarifier sludge blanket depths. Increased automation and availability for better control will improve management; however, this method is already used during high losses and has proven insufficient to meet the Modeling Report limits.
11. *Tertiary Sand and Disk Filtration* – Both sand filters and the cloth Aquadisk filters were considered; however, these options are more costly than a DAF and are unproven technology. The tertiary treatment option of Dissolved Air Flotation (DAF) is addressed below.
12. *Polishing Pond* – A polishing pond would assist in removing daily maximum BOD and TSS events; however, this technology was ruled out due to routine sediment removal requirements, the lack of available space, and the potential for phosphorus release across the pond.
13. *Ozone Bleaching (Z, DZ, ZD)* - The various forms of ozone bleaching have different process configurations and process needs; however, none of the forms of ozone bleaching decrease BOD or flow appreciably unless the filtrate is recycled. Applications of Z bleaching are preceded by oxygen delignification stages (addressed below) not presently employed by the Rumford Mill. The ZD and DZ applications may be utilized to support filtrate recycle options that are subsequently discussed under Bleach Filtrate Recycle and Alkaline Filtrate Recycle.
14. *Oxygen Delignification* – The cost of oxygen delignification without upgrades to brownstock washing or causticizing is approximately $50 million (source: McCubbin, Review of Current Technology for Control of Dioxin Discharge in Effluents from Kraft Pulp Mills). This cost plus the upgrades to washing and causticizing would provide a reduction in bleaching costs that is insufficient to support the capital investment. This technology has significant costs; yet, would not provide the clarifier offloading that the aeration basin increase provides.
15. *Bleach Filtrate Recycle (BFR)* – This process has been implemented in only one mill in the world and cites oxygen delignification as a "cornerstone" of the process. The cost is roughly $50 million plus for oxygen delignification and approximately $30 million for the BFR technology for an estimated total of over $80 million. The technology is proven only at one mill and replicating these results may take years, if accomplished. The operating cost is substantial. The combined flow and BOD reduction from this technology would provide a similar clarifier offloading as increased aeration but at a much greater cost.
16. *Alkaline Filtrate Recovery* - The acidic filtrate has a greater fraction of more biodegradable (BOD) components while the alkaline filtrate has a greater fraction of less biodegradable (COD rather than BOD). A high degree of alkaline filtrate recovery achieved by some TCF mills (TCF reviewed below) may reduce the bleach plant BOD loading and flow by as much as 50%. The authors are not aware of alkaline filtrate recovery in ECF mills greater than 5 to 33% of the total mill alkaline filtrate streams. The authors are also not aware of any applications in ECF mills without two stage oxygen delignification or oxygen delignification plus ozone (OZED-Franklin, Virginia) which reduces the chloride content of the filtrate. Scaling problems have been reported in these applications. The costs of alkaline filtrate recovery include greater than $50 million for oxygen delignification, several million for a chloride removal process, and increased operating costs as well as lost opportunity due to reduced pulping capacity. The degree of filtrate recovery would be insufficient to provide a sufficient flow and BOD load reduction to affect the wastewater treatment plant performance.

17. *Totally Chlorine-Free (TCF) Bleaching* – The cost of a TCF conversion for the Rumford mill is approximately $150 million (McCubbin) without upgrades to the pulping and woodyard (chip screening) operations that often accompany TCF bleaching. The bleach chemical savings are insufficient to justify this magnitude of capital investment. Filtrate recycling is necessary to reduce flow and BOD. The reduced pulping capacity and operating cost increase associated with filtrate recycling would offset the bleach chemical savings. TCF filtrate recycling would provide offloading of the treatment plant but at a cost that is much greater than other reviewed options.
18. *Dissolved Air Flotation* - This option involves installing dissolved air flotation (DAF) after the secondary clarifiers to provide a TSS and insoluble BOD reduction prior to discharging the treated effluent. DAF technology would be effective at reducing the magnitude of the occasional secondary effluent TSS and associated insoluble BOD spikes. This technology would be expected to outperform the Modeling Report monthly TSS limit and meet the daily TSS and monthly BOD limits. Daily BOD would improve to either meeting or nearly meeting the Modeling Report daily BOD limit. DAF technology would improve effluent quality on a day-to-day basis, including reduced particulate phosphorus levels. DAF and associated equipment has a footprint small enough to fit in the space-constrained area near the secondary clarifiers.

    The negative aspects of DAF are that it would require significant capital and have few applications in an integrated Kraft pulp and paper mill in North America. The estimated capital cost for installation would be prohibitive, at approximately $9 million. Annual operating costs would be estimated at $1 million. Although DAF is a proven technology in some applications, it has not been widely employed to reduce BOD and TSS loadings from secondary effluents in the pulp and paper industry. Literature notes that sludge disposal costs would be expected to increase since sludge from these units can be difficult to manage. This DAF technology would require a more detailed review before its could be considered viable; including site visits and a pilot plant trial to more fully evaluate costs and performance expectations due to the limited application of this technology to pulp and paper mills.
19. *Curtail Mill Production* – Reduction of BOD, TSS, and flow loading from the mill could be achieved by permanently curtailing the pulp production capacity of the Rumford Mill. A permanent curtailment of 25% of pulp production capacity for the Rumford Mill would result in an estimated $18,000,000 per year in lost opportunity. A permanent curtailment of 50% of pulp production capacity would result in an estimated $45,000,000 per year in lost opportunity for the Rumford Mill. It is clear that these losses would result in a major restructuring of the Rumford Mill. Restructuring options would include permanent retirement of paper production and pulp production assets which would subsequently result in a restructuring of the mill workforce as well. Changes of this magnitude would have a permanent impact on the local, regional, and statewide economy. The US Department of Commerce estimates the indirect impact of an event of this magnitude at 4 times the direct cost impact.

APPENDIX B – AUTHORS

Michael Sinclair – Registered Professional Engineer. B.S. from University of Maine in Chemical Engineering summa cum laude with publications on computer process modeling. 8 years experience in the pulp and paper industry. 2 years providing pulp mill engineering for process optimization, trials, and upgrades including lead engineer role in ECF bleaching conversion. 3 years supervising bleach plant, chlorine dioxide plant, and pulp dryer production operations and personnel. 3 years environmental engineering experience providing process and regulatory support to pollution prevention programs and the landfill and wastewater treatment operations.

Stephen Fuller - Registered Professional Engineer. B.S. from SUNY, Syracuse Pulp and Paper Engineering. 28 years of experience in the pulp and paper industry in the pacific northwest and the northeast. 21 years in project management and capital engineering, and 7 years managing the waste water treatment facility in Rumford, Maine. Winner (with Steve Woodard) of best technical paper award at TAPPI 2002 International Environmental Conference. Licensed Grade V State of Maine biological wastewater treatment plant operator.

Steve Woodard - Registered Professional Engineer. Ph.D. from Purdue University in Environmental Engineering. Worked at over 30 mills assisting with wastewater issues, including troubleshooting and design. Winner (with Steve Fuller) of best technical paper award at TAPPI 2002 International Environmental Conference. Published several papers and taught in several workshops on industrial waste treatment and plant optimization.